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Research Article
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Human Casualties from Human-Elephant Conflict around Koshi Tappu Wildlife Reserve, Nepal

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Abstract. We studied human casualties in the buffer zone of Koshi Tappu Wildlife Reserve to gain insights into the factors responsible for elephant attacks on humans. We interviewed victims' families for those that got killed and victims that got injured, over the past six years. Human behaviour was responsible for more casualties than elephant behaviour. Casualties were mainly caused by people's negligence of threats and confrontation of elephants. Providing awareness about elephant ecology and training people about deterrents and methods for avoiding conflict, along with regular patrolling and maintenance of electric fences is required to ensure the safety of both people and elephants.

Introduction

In recent times, one of the most pressing challenges in wildlife conservation in Nepal is the human-wildlife conflict, with Asian elephants (*Elephas maximus*) being particularly prone to conflicts (Acharya *et al*. 2016; Ram *et al*. 2021). Approximately 20% of the human population resides near wild elephant habitats in South Asia (Bandara & Tisdell 2003). The conflict between humans and elephants has escalated due to expanding human settlements and habitat loss and fragmentation.

The Asian elephant population in Nepal has increased significantly from 105–125 in 2002 (Kharel 2002) to 109–142 in 2010 (Pradhan *et al*. 2011) and to 203–227 individuals in 2022, distributed across six clusters (Ram *et al*. 2022). Historically, elephants inhabited Nepal's undisturbed lowland forests (Olivier 1978; Smith & Mishra 1992) and the Chure Foothills across Nepal (Thapa *et al*. 2019; Ram *et al*. 2022), which extend from the Brahmaputra River in India in the east to the Indus River in Pakistan in the west, covering 13% of the country's land area. Currently Asian elephants are distributed across the Terai region of Nepal and present in 22 of the 77 districts of Nepal.

Elephant attacks account for approximately 40% of human-wildlife conflicts and 70% of wildlife-related human casualties in Nepal (Bajimaya 2012). The Jhapa District in the eastern lowland region has a particularly high number of human-elephant conflict (HEC) incidents (Pradhan *et al*. 2011; Ram 2014). In Koshi Tappu Wildlife Reserve (KTWR) as well, there is a very high number of conflicts, which can be attributed to the migration of elephants from the Chure region, limited habitat area within the reserve and limited possibility of movement to areas beyond the reserve (KTWR Office 2018).

Research in Nepal has explored crop and property damage caused by elephants (Graham *et al*. 2012; Neupane *et al*. 2014; Pant *et al*. 2016; Gross *et al*. 2022). However, few studies have focussed on elephant attacks on humans. Ram *et al*. (2021) conducted a study across the Terai and Siwalik regions, which showed people who

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were drunk and chasing elephants using firecrackers were at higher risk of fatalities.

We conducted situation analyses to assess whether the causation of HEC incidents around KTWR was due to humans, elephants or accidental, and to assess the potential for minimising them through modifying human behaviour.

Materials and Methods

Study area

The study area covers the buffer zone of KTWR, which lies within 86°53'41" – 87°06' 32"E longitude and 26°33'58" – 26°43'42''N latitude. It lies across the three districts Sunsari, Saptari and Udaypur in Koshi Province of the Federal Republic of Nepal covering 5 municipalities and one rural municipality. A buffer zone was declared in 2004 covering 173 km^2.

The core area of KTWR is 175 km^2 in extent. The habitat in the core area consists of mixed deciduous riverine forest alongside the Koshi River. The habitats within the reserve consist of grasslands (53%), river (22%), forest areas (10%) and sandy riversides (15%) (KTWR Office 2018). The boundary of the core area with the buffer zone represents the forest edge. Unlike other protected areas, KTWR has only a few forest patches in its buffer zone. The land use in the buffer zone consists of agricultural land, grasslands, settlement areas, rivers and very little areas with tree cover. Out of the 55 km of the perimeter of the reserve, on about 18 km a solar fence has been constructed to prevent

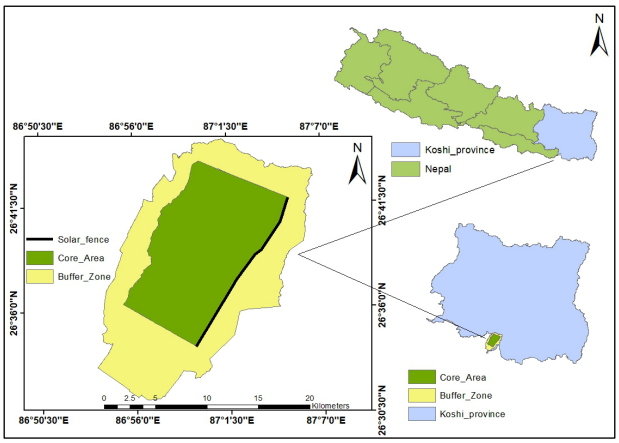


Figure 1. Map of study area.

wild water buffaloes and wild elephants from entering the buffer zone (KTWR Office 2018) (Fig. 1). The buffer zone is surrounded by settlement areas and agricultural lands in the east, west and south, and by the Chure forests to the northwest.

The Reserve experiences a subtropical monsoon climate, with distinct seasons: spring, summer, autumn, and winter. Spring (February – April) brings pleasant warm temperatures and strong winds. Summer (May) is hot, reaching temperatures up to 40°C with minimal rainfall whereas autumn (August – October) accounts for 80–85% of the total annual rainfall. Winter (November – January) features clear skies, cold mornings, and warm days with the lowest temperature of 3.3°C in January. The area receives some winter rain from south-westerly winds. The average annual rainfall is 2019 mm, with daily maximum temperatures ranging from 23.5 to 33.4°C, and minimum temperatures between 7.8 to 25.3°C. Monthly average temperatures range from 15.7 to 29.2°C. Humidity remains consistently high throughout the year, with monthly averages ranging from 76 to 94% (DHM 2017).

Data collection

Data on human casualties caused by Asian elephants over the past six years was obtained from the official records of the KTWR office where the office personnel maintain comprehensive information gathered from detailed field reports. After visiting all locations of the reported incidents, semi-structured interviews were conducted with the victim's family members for deaths, and the victims interviewed in the case of injuries. Information such as gender, age, and occupation as well as causes of conflict, time (year, season, time of day), location of the house, location of the incident, number of elephants involved, mitigation measures applied and people's perception on the elephant attacks were obtained.

About 10–12 elephants are thought to occur in KTWR and the surrounding area. The elephants in KTWR especially males, either singly or in groups, spend a lot of time in and around the buffer zone near crop fields and in the vicinity

of settlement areas. As they are frequently seen during the day and night-time patrolling, the residents and the office staff knew many of them. Male elephants without tusks, are locally referred to as 'Makuna'. There was only one such 'Makuna' in KTWR and he was sometimes observed alone and at other times associating with herds. Makuna has been in the KTWR since 12 years and has never left it. The verification of which elephant caused a death is conducted by a team of experts from the reserve, in collaboration with the police, and involved an investigation based on information provided by local people. In cases of human fatalities, other people were often present at the incident and could provide details.

Measures practiced by respondents were grouped into five categories. They were deterrents, patrolling, physical barrier, awareness and training and compensation. Deterrents consisted of making noise using household items and use of fire. Patrolling means evening-to-early-morning patrolling by a joint team of wildlife and army officers along the boundary of the core area and buffer zone, where the solar fence is located. Physical barriers refer to fences, trenches and thorny bushes. Awareness refers to educating the local residents regarding elephants i.e. their behaviour and ecology, their historical range across lowlands of Nepal, causes of HEC and ways of conflict mitigation. Training refers to teaching of efficient ways to chase elephants without risking their lives. Compensation refers to the financial aid given by the government as a relief for the damage from HEC incidents.

Measures recommended by respondents to mitigate HEC were also categorised into five. They were: Proper electric fencing, proper patrolling, awareness and training, fencing around residential area and removing all elephants. Proper electric fencing means good maintenance and timely repair of fences if elephants break them. Fencing around residential area means electrifying boundaries with mains current around homes and adjoining land, activated particularly during night-time. Removing all elephants means translocation of the elephants from KTWR to other protected areas.

The respondents were asked to rank their responses for both the currently being practiced and recommended mitigation measures, on a scale of 1 to 5, with 5 indicating the highest rank, based on their perceived effectiveness.

Data analysis

The data was fed into Kobo collect toolbox and sorted into different topics. Analysis was done with IBM SPSS Statistics 25 and R statistical package v. 4.2.1. The distance of incidents and core area of the reserve was measured in Google Earth. Kernel density mapping was done to identify high HEC areas. Chi-square test was used to compare the significance of the frequency of incidents between variables. The Friedman ANOVA test was used to check the significance between the average mean score of the measures.

Results

Most incidents happened when people were chasing elephants (χ^2 = 10.118, df = 4, P = 0.038) (Fig. 2) and elephants were raiding crops (χ^2 = 6.05, df = 2, P = 0.048) (Fig. 3).

Solitary adult bulls were responsible for more incidents than groups (χ^2 = 9.529, df = 1, P = 0.002). Among the solitary bulls, Makuna was found to be involved in most cases (61.7%, n = 21) (Table 1).

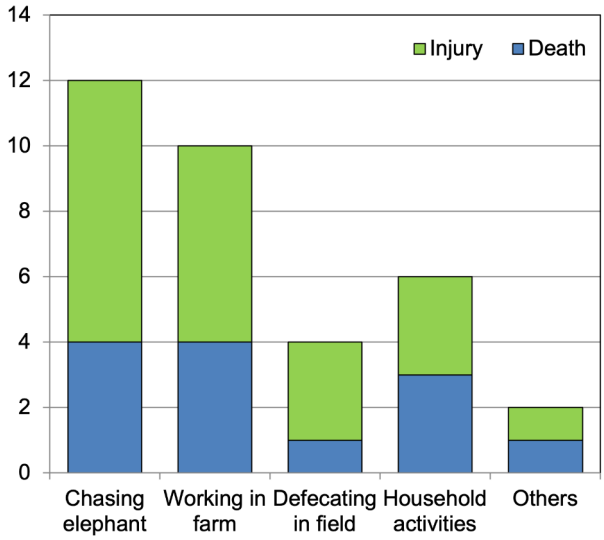


Figure 2. Human activity at the time of HEC incidents.

Table 1. Elephants involved in HEC incidents.

Elephants	Death	Injury	Total
Solitary			
Makuna	4	10	14
Other single male	6	6	12
Group			
with Makuna	2	5	7
without Makuna	1	0	1
Total	13	21	34

Spatial distribution of human casualties

Human casualties occurred at locations between 60–5515 m from the boundary of the core area (mean = 1250 ± 1500 m, n = 34). A total of 47.1% of incidents (n = 16) were less than 500 m away from the core area boundary and the rest (52.9%, n = 18) were more than 500 m from the boundary (Fig. 4). Casualties occurred within the buffer zone comprising all 5 Municipalities and 1 Rural Municipality, maximum being in the Koshi Rural Municipality (50%, n = 17) (Fig. 4).

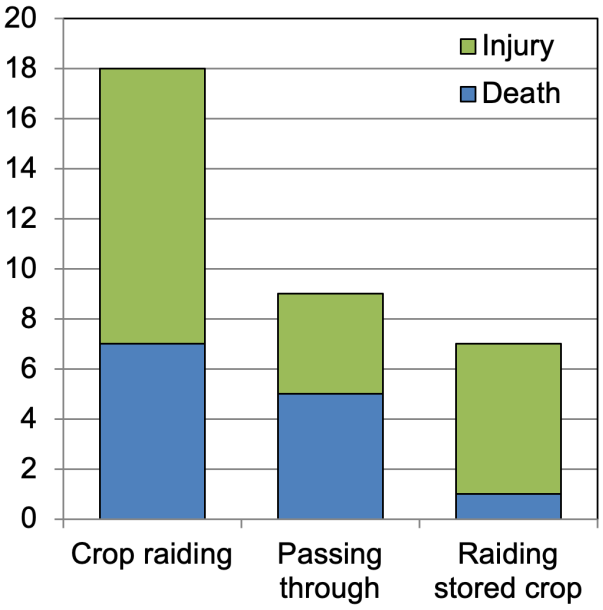


Figure 3. Elephant activity when HEC incidents occurred.

The largest Kernel density hotspot was concentrated in the Koshi Rural Municipality with an extremely high-risk area close to the core area boundary (Fig. 5). A second hot spot with a smaller extremely high-risk area was detected

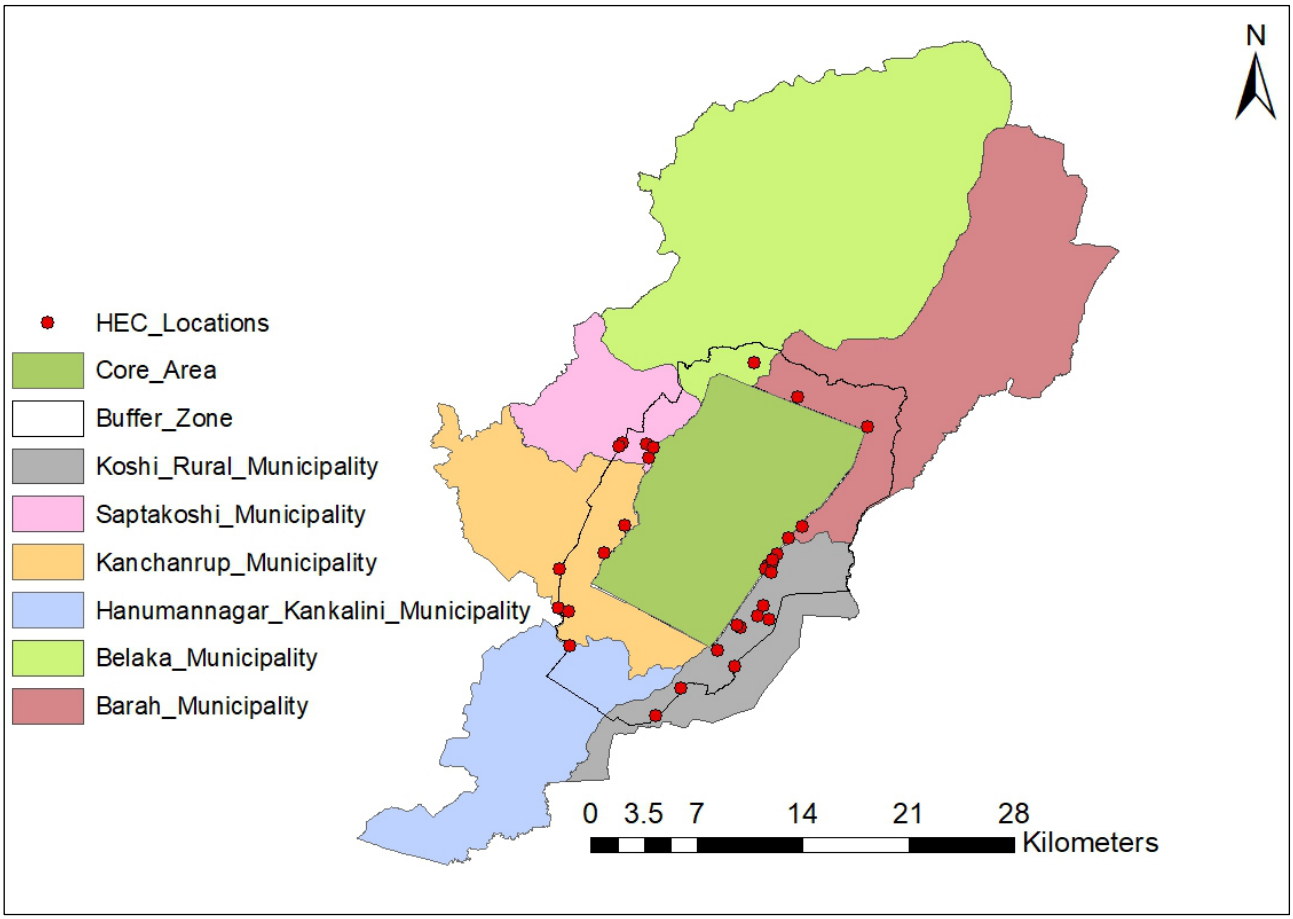


Figure 4. Human casualties in municipalities in the KTWR buffer zone.

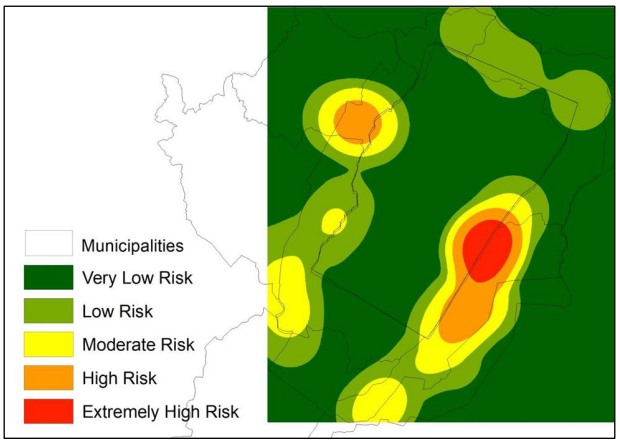


Figure 5. Kernel density map of incidents.

in the Saptakoshi Municipality (Fig. 5). Most incidents (35.3%, n = 12) happened in crop fields (Fig. 6).

Temporal pattern of HEC incidents

From 2015 to 2018, casualty cases were equal in number. The number of incidents peaked in 2019 followed by subsequent decrease in 2020 (Fig. 7). Most incidents occurred in winter (35.3%, n = 12) followed by summer (26.5%, n = 9), autumn (26.5%, n = 9) and spring (11.8%, n = 4) (Fig. 8). Regarding the time of the day, incidents mostly occurred in the night (Fig. 9).

Causes of HEC incidents

Human actions accounted for 25 cases (73.5%), elephants' actions were responsible for 2 (5.9%) and 7 (20.6%) were accidental (Table 2). Most victims were adult male farmers (Table 3).

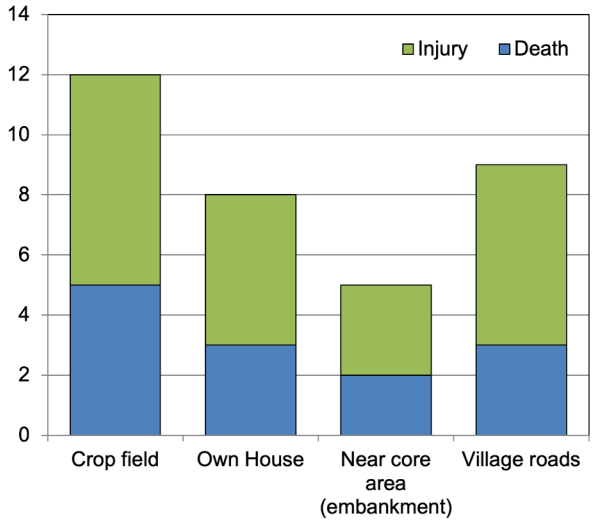


Figure 6. Land use of locations where HEC incidents occurred.

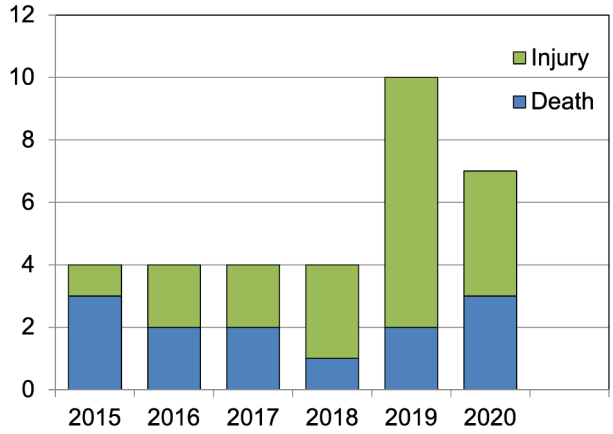


Figure 7. Yearly HEC incidents.

The majority of respondents agreed that the incident could have been avoided (76.5%, n = 26), 7 had no opinion (20.6%) and one respondent

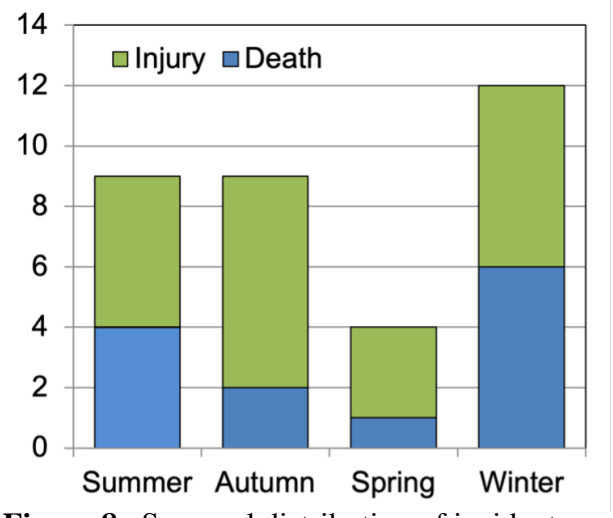


Figure 8. Seasonal distribution of incidents.

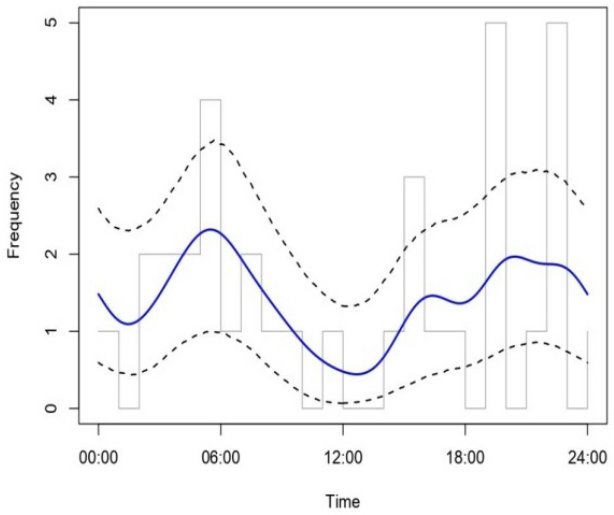


Figure 9. HEC incidents by time of day. Columns outlined in grey are observed frequencies of incidents, blue curved lines are fitted circular kernel distributions, dotted black lines are upper and lower confidence interval limits.

Table 2. Causes of HEC.

Category	Nature of incidents	Cases
Human activities	Running away from elephants	8
	Working in the field in the early morning and late nights	3
	Chasing elephants	5
	Defecating in the field in the early morning and night-time	4
	Shouting from outside house	1
	Celebrating festival at midnight	1
	Checking for elephants in the bushes	1
	Sleeping outside the house	1
	Sleeping in the field	1
Elephant activities	Raiding stored crops	1
	Damaging house	1
Accidents	Encounter in crop field during afternoon	3
	Elephant coming out of bushes and chasing a long distance while herding	1
	Elephant encounter due to dense fog in crop field	1
	Elephant attack on mentally unfit person within elephant migratory path, on foggy evening	1
Total		34

believed that the incident was unavoidable (2.9%).

The majority (52.9%, n = 18) supported keeping elephants in the reserve while the rest were negative towards it.

All respondents knew about compensation schemes for damage caused by elephants.

Measures to mitigate HEC

There was a significant difference between the average ranks of the mitigation measures practiced by respondents to control HEC incidents ($\chi^2 = 96.067$, df = 4, $P < 0.001$), with deterrents receiving the highest ranking (Fig. 10).

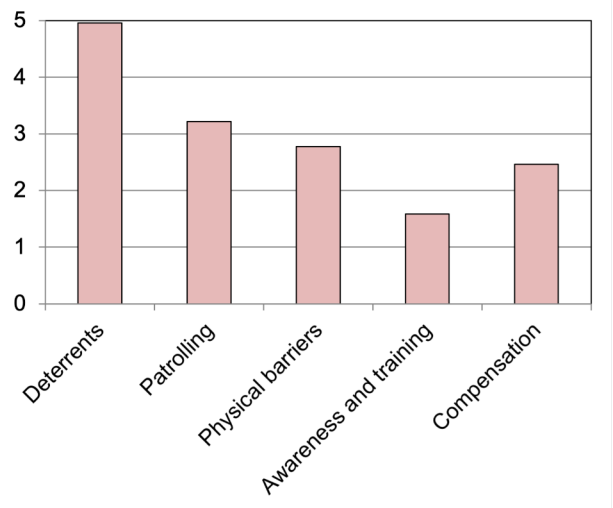


Figure 10. Mean rank of practiced mitigation measures.

There was a significant difference between the average ranks of the mitigation measures to control HEC incidents recommended by respondents ($\chi^2 = 115.436$, df = 4, $P < 0.001$), with proper patrolling receiving the highest ranking (Fig. 11).

Table 3. Socio-economic and demographic characteristics of human casualties.

Characteristics	Death	Injury	Total
Sex			
Female	5	4	9
Male	8	17	25
Age			
<15	1	1	2
15-24	1	1	2
25-44	5	8	13
45-64	4	8	12
65+	2	3	5
Occupation			
Farmer	6	11	17
Business	1	2	3
Government employee	1	3	4
Unemployed	3	2	5
Other	2	3	5
Total	13	21	34

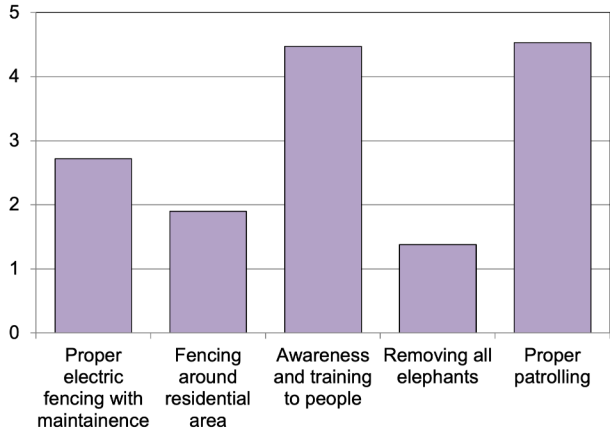


Figure 11. Mean rank of recommended mitigation measures by respondents.

Discussion

Factors causing casualties

We found that the significant number of casualties occurred while chasing elephants. Nelson *et al*. (2003) and Ram *et al*. (2021) also found that most human casualties happened due to aggressive human behaviour towards elephants. We also found casualties of men were much more than that of women. The male bias in casualties could be due to their greater participation in chasing elephants (Sarker *et al*. 2015; Karki 2018) and greater involvement in fieldwork (Ram *et al*. 2021).

Solitary bulls caused significantly more incidents than groups. Among them, Makuna, the tuskless bull elephant of KTWR was identified as being responsible for most cases (61.7%). According to Ram *et al*. (2021) a few individual bulls that regularly entered human settlements and agricultural areas, were involved in the majority of attacks on humans in Nepal. Similar findings of attacks on humans by solitary bulls are reported in south-east Bangladesh (Sarker *et al*. 2015). Such individuals can be termed "problem individuals" (Lamichhane *et al*. 2017; Swan *et al*. 2018). Our findings highlight the necessity of conflict mitigation strategies for problem bulls like Makuna, around KTWR and other protected areas. We recommend conducting awareness programs about the behaviour of such animals and early warning systems that can be employed to warn residents about the presence of such animals in their neighbourhood.

We found a significant number of incidents happened in farmland when elephants were crop raiding, than when they were passing through or raiding stored crops. Sarker *et al*. (2015) found that in Bangladesh within the period 1989–2012, most casualties happened outside forest areas by elephants in search of food. Acharya *et al*. (2016) also observed that in Nepal most of the elephant attacks occurred in farmland. Therefore, our results are consistent with findings by other studies and appear to show a pattern widespread in Asian elephant range.

We found that an equal number of incidents occurred at a distance of less than 500 m and more than 500 m from the core area boundary of KTWR. Therefore, the number of incidents per unit area was higher within 500 m from the core. A study of HEC incidents across Nepal indicated that approximately two-thirds of elephant attacks on humans took place within 500 m from the forest edge (Ram *et al*. 2021). The somewhat lower incidence observed by us might be attributed to the smaller sample size in our study, land use and physical characteristics of the area around KTWR or elephants venturing out further from the core area than in the past. As about half of the incidents happened within 500 m of the core area, individuals residing nearer the core area faced higher vulnerability to elephant attacks. This may be due to factors like greater likelihood of encountering elephants closer to the forest, areas closer to the core being inhabited by marginalised communities residing in houses which offer little protection against elephants, and lower levels of education and awareness (Pant *et al*. 2016; Ram *et al*. 2021).

The residents of Koshi Rural Municipality faced a heightened vulnerability to HEC incidents compared to other areas. This may be due to elephants using the area more intensively, as groups of elephants are frequently seen near agricultural fields along the border of Koshi Rural Municipality and the core area. In western Nepal, male elephants caused HEC incidents primarily when they sought oestrous females in elephant stables (Shrestha *et al*. 2007) and in central Nepal settlements experiencing high HEC were often located in proximity to ele-

phant stables in protected areas (Pant *et al*. 2016). The location of stables with captive female elephants at the head office of KTWR, which is in Koshi Rural Municipality, could be another contributory factor for the high HEC there. This indicates that Koshi Rural Municipality is a priority for HEC mitigation.

During the study period, the number of HEC incidents remained static over the first few years but sharply increased in 2019, followed by a subsequent decrease in 2020. However, there was no clear reason observed for such ascent followed by a decline.

We found there were a higher number of HEC incidents in winter. Similar findings were observed in Central and Western lowland of Nepal by Shrestha *et al*. (2007) and in Chitwan National Park, Nepal by Dangol *et al*. (2020). The increase of incidents in winter may have been due to shorter daylight hours and foggy conditions, which persist throughout the day in the lowland areas of Nepal (Acharya *et al*. 2016; Karki 2018). It is crucial to raise awareness among people about taking precautions during the winter, as this season witnesses a higher frequency of HEC incidents.

We observed that most incidents occurred during early morning and from evening until midnight. Similarly, Neupane *et al*. (2014) reported that 70% of incidents in Nepal in 2003–2012 occurred from evening to early morning, Ram *et al*. (2021) that a high number of incidents happened during evening and Sarker *et al*. (2015) that about 58% (n = 130) of incidents occurred at similar times in Bangladesh. Elephants mostly raid at night and tend to return to forest areas early morning. During raiding, people often take risks in trying to chase away the elephants, putting them in danger. People may also be injured or killed by falling debris when elephants damage houses in search of stored crops, which also happens in the night.

Causes of HEC

The situation analysis revealed that humans bear most responsibility for the causation of HEC incidents. Similarly, Karki (2018) found 75% of incidents in Bardiya and Shuklaphanta National Parks in Nepal and Sunar (2017) found 55% of incidents in Jhapa, Nepal, were due to human actions. We found negligence of safety when chasing elephants, underestimating their speed and defecating outside at night-time or sleeping in the fields were mainly responsible for causing incidents, which were also cited by Karki (2018) and Ram *et al*. (2021). Nelson *et al*. (2003) suggested that aggressive human behaviour characterised by intolerance towards elephants is the primary cause of conflict incidents as the majority of incidents occurred while chasing elephants using firecrackers, loud sounds and bright lights.

Electric fencing stands out as the most effective method for preventing elephants from entering community areas. A majority of incidents occurred during attempts to chase elephants that had entered fields or approached households. Therefore, if the fence is breached and elephants enter the fields, vehicles like tractors and jeeps should be used to drive the elephants back into the forest by the night elephant patrolling team as they do now in KTWR. Many respondents recognised that incidents could have been prevented, by exercising greater caution, understanding of elephant behaviour and adherence to safety protocols. Therefore, we propose that if community members participate in chasing elephants, they keep a distance of at least 100m from elephants. However, as most people may not know proper techniques to chase elephants and as crop damage will then anyhow occur, staying away from the elephants and later obtaining compensation may be a better option. Additional research is needed to examine the efficacy of programs and administrative processes, to determine whether the current compensation system is adequate.

Perception of respondents regarding HEC

The majority of respondents had a positive attitude towards elephant conservation in KTWR. Around half of the people surveyed expressed their support for retaining the elephants instead of removing them. Similar findings were observed by Karki (2018) in Bardiya National Park. Therefore, implementing awareness and

educational initiatives focused on elephant behaviour such as their historical pathways across lowland of Nepal, their ecology, reasons for HEC, ways to minimise it and promoting peaceful coexistence can assist in elephant conservation and reducing conflicts.

Measures to mitigate HEC

The most utilised measures to address HEC were deterrents such as noise and fire, followed by regular patrolling by the operating team of KTWR, physical barriers, compensation, and awareness and training. The respondents' recommended mitigation measures indicated prioritising proper patrolling, followed by implementing awareness and training programs, timely maintenance of electric fencing to effectively mitigate HEC incidents. These results strongly indicate that providing awareness and training programs to the local population, enlightening them on mitigating HEC incidents and equipping them with appropriate methods to ensure their safety is a priority.

In conclusion our findings suggest that people are mainly responsible for human casualties due to HEC and that they mainly occur due to negligence and lack of knowledge regarding elephant behaviour and ecology, causes of HEC, and ways of conflict mitigation.

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